Attachment to
Cellular Telecommunications & Internet Association
Comments

ET Docket No. 03-237

Before the
FEDERAL COMMUNICATIONS COMMISSION

Don't Let Short-Term Reforms Interfere with Long-Term Policy Goals

Report of Michael L. Katz

ET Docket No. 03-237

5 April 2004

CONTENTS

I. QUALIFICATIONS AND STATEMENT OF WORK

1. My name is Michael L. Katz, and I am the Sarin Professor of Strategy and Leadership at the University of California at Berkeley. I hold a joint appointment in the Haas School of Business Administration and the Department of Economics. I have also served on the faculty of the Department of Economics at Princeton University. I received my A.B. from Harvard University *summa cum laude* and my doctorate from Oxford University. Both degrees are in Economics.

2. I specialize in the economics of industrial organization, which includes the study of antitrust and regulatory policies. I regularly teach courses on microeconomics and business strategy. I am the co-author of a microeconomics textbook, and I have published numerous articles in academic journals and books. I have written academic articles on issues regarding the economics of network industries, systems markets, telecommunications policy, and antitrust enforcement. My curriculum vitae is attached to this report as Attachment 1. It lists all publications that I have authored or co-authored, with the exception of a few letters to the editor on telecommunications and antitrust policy. I am recognized as one of the pioneers in extending the theory of network effects to competitive settings. I am a co-editor of the *Journal of Economics and Management Strategy* and serve on the editorial board of the *California Management Review*.

3. In addition to my academic experience, I have consulted on the application of economic analysis to issues of antitrust and regulatory policy. I have served as a consultant to both the U.S. Department of Justice and the Federal Communications Commission ("Commission") on issues of antitrust and regulatory policy. I have served as an expert witness before state and federal courts. I have also provided expert testimony before a state

regulatory commission and the U.S. Congress.

4. From January 1994 through January 1996, I served as the Chief Economist of the Commission. I participated in the formulation and analysis of policies toward all industries under Commission jurisdiction. As Chief Economist, I oversaw both qualitative and quantitative policy analyses.

5. From September 2001 through January 2003, I served as the Deputy Assistant Attorney General for Economic Analysis at the U.S. Department of Justice. I directed a staff of approximately fifty economists conducting analyses of economic issues arising in both merger and non-merger enforcement. Our principal professional focus was on understanding and projecting the impacts of various business practices and public policy decisions on consumers' economic welfare. My title as Deputy Assistant Attorney General notwithstanding, I am not an attorney.

6. I have been asked by counsel for the Cellular Telecommunications & Internet Association ("CTIA") to examine from the perspective of economics the likely efficiency and consumer welfare effects of applying to Commercial Mobile Radio Services ("CMRS") frequency bands certain spectrum management policies identified by the Notice of Inquiry and Notice of Proposed Rulemaking in this proceeding.[1] Drawing on my training and experience as an economist, my review of the record in this matter, and my analysis of the relevant industries, I find that it would not be in the public interest to use the interference temperature metric to establish a government-mandated underlay rights in CMRS frequency

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[1] *In the matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands,* Notice of Inquiry and Notice of Proposed Rulemaking (hereafter, NOI & NPRM), ET Docket No. 03-237, rel. November 28, 2003.

bands at this time. This report explains the factual and logical analysis that leads to these conclusions.

II. OVERVIEW OF OPINION

7. The Commission has correctly determined that there is a need for dramatic and systematic reform of spectrum management, and the Commission is considering a number of innovative proposals. However, even though the Commission faces tremendous pressures to reform spectrum management in ways that will increase the economic efficiency of spectrum use in the short run, it also is vital to long-run economic welfare that the Commission not implement new policies too quickly. Specifically, the Commission should take care not to implement unproven policies that would prove difficult to reverse even if they were found to be costly and inefficient once put into effect. The use of an interference temperature metric to implement government-imposed underlay rights within CMRS frequency bands is one such policy. Given the inchoate state of the proposals to create underlay rights for so-called unlicensed devices using the interference temperature metric, as well as the difficulties that would be encountered in trying to reverse these policies should they prove to be seriously flawed, there is a real potential for these policies to cause significant long-term harm to consumers and economic efficiency.

8. The proposed policies raise two types of concerns. First, these policies may simply be the wrong reforms. As explained below, creation of government-imposed underlay rights perpetuates the command-and-control approach to spectrum management that the Commission has rightly recognized as severely flawed in most contexts. From the perspectives of consumer welfare and economic efficiency, a more appropriate approach is to rely on competitive market forces wherever possible. It is widely recognized among

economists and policy makers that—except in certain well-defined circumstances—"the market" is better able to process information regarding the benefits and costs faced by millions of market participants than is any government agency, no matter how well-intentioned or resource rich. Second, even if government-mandated creation of underlay rights based on an interference temperature metric ultimately proves to be a good policy in some circumstances, putting this policy in place too quickly or in the wrong frequency bands might have harmful consequences for consumers of the incumbent services in those bands where underlay rights were created.

9. Briefly, my findings with respect to the concerns raised by mandatory underlay rights based on an interference temperature metric are the following:

- *Government-imposed underlay rights perpetuate the command-and-control approach that the Commission has recognized as severely flawed in most contexts.* The level at which an interference temperature floor/ceiling is set is a critical dimension of public policy that will affect the welfare of underlay rights users as well as of the customers of the carriers holding the incumbent licenses. Under the approach proposed in the *NOI & NPRM,* this floor/ceiling would be set by government fiat. Moreover, to a large extent, so-called "unlicensed" underlay rights would rely on mandatory protocols and etiquettes that would dictate what users can do, rather than rely on market forces. Further, these types of government-imposed rules are not technologically neutral and would distort innovation and investment incentives.
- *The Commission does not—and will not—possess the information and ability to set an interference temperature floor/ceiling at a level that will maximize consumer welfare and promote economic efficiency in frequency bands such as those used for CMRS.* At present, the Commission simply does not have the information needed to make an informed choice. More important, on a going-forward basis, the Commission has no practical way of determining the costs and benefits to potentially millions of users from setting the floors/ceilings at various levels in CMRS and similar bands.
- *Regulation generally is not needed to create underlay rights and promote efficient use of the spectrum.* Rather than creating mandatory underlay rights, the Commission could rely on primary users' sublicensing through secondary markets. If underlay rights are efficient, then in most situations market forces can be expected to generate economic incentives for the creation of underlay rights. Private market participants might or might not choose to use an interference temperature approach. Indeed, one might expect a number of different approaches to be taken, initially on an experimental basis and in the long run to reflect differences across bands and primary

users.

- *From the perspective of consumer welfare and economic efficiency, a better approach to reforming spectrum policy would be to allow licensees greater flexibility and the increased ability to sublicense spectrum.* CMRS consumers have benefited from the flexibility that the Commission has granted licensees, and similar gains could be had elsewhere. The Commission has been removing regulatory obstacles to secondary markets and it should continue along this path to reform.
- *The interference temperature concept is not fully developed and may be the wrong measure from the perspectives of both engineering and economics.* As the *NOI & NPRM* recognizes, there are numerous unanswered technical, logistical, and policy questions concerning implementation of an interference temperature metric. There is a lack of field experience with the concept, and there is no measurement network in place. Moreover, the Commission has not identified a workable enforcement mechanism.
- *CMRS frequency bands are the wrong place to experiment with underlay rights.* CMRS has a number of characteristics that make its frequency bands particularly unsuitable for this type of experimentation. These characteristics include the existence of a huge number of mobile transceivers that are sensitive to interference and many of which serve high-value functions (*e.g.,* 9-1-1 calls and other consumer safety functions or enabling a sole proprietor to operate her business efficiently). An interference temperature measurement scheme would be difficult to implement in this environment, and an experiment gone awry could be very costly to large numbers of consumers, as well as very costly to fix. Finally, the creation of significant mandatory underlay rights would very likely reduce the incentives and ability of CMRS incumbent licensees to innovate and invest.

10. The remainder of this report explains these conclusions in greater depth and provides details of the facts and analysis that led me to reach them.

III. MARKET FORCES ARE PREFERABLE TO GOVERNMENT FIAT IN CREATING UNDERLAY RIGHTS

11. The Commission is right to look at multiple dimensions of spectrum management, including frequency, time, and location. The Commission is also right to conclude that spectrum usage models ideally will look at real-time, localized measures of interference. A fundamental issue, however, is whether this is better done by regulation or competition.

12. There is a broad consensus among economists and other policy analysts that market forces are preferable to regulation where possible. A central reason why this consensus has

developed is that a regulatory body will be unable to collect the information necessary to determine the quantities, quality levels, and terms of service that maximize consumer welfare given the nature of costs and technology. This is the reason why, for example, economists generally oppose government-set prices for consumer goods except in very rare circumstances. The logic and force of this broad consensus applies to spectrum management.

13. One of the fundamental objectives of spectrum management reform is to use spectrum more intensively and to facilitate entry by new users, when and where efficient. Technological advances are creating greater opportunities for multiple non-interfering uses, thus facilitating both increased intensity of spectrum use and the possibility of new entry. There are, however, multiple ways to facilitate sharing. Two of those ways are government-mandated underlay rights ("easements") and voluntary sub-licensing ("secondary markets"). Under an easement approach, the Commission would establish conditions for new users to operate in frequency bands in which incumbent license holders already operated. Under a secondary markets approach, the incumbent licensees would determine which potential entrants could have access to the spectrum and under what terms and conditions. The first approach relies on government fiat and the second on market forces.

A. GOVERNMENT-IMPOSED UNDERLAY RIGHTS PERPETUATE THE COMMAND-AND-CONTROL APPROACH THAT WILL DISTORT INNOVATION AND INVESTMENT

14. One man's ceiling is another man's floor. Under the Commission's proposed policies, an interference temperature would serve as a ceiling on the operations of underlay users, and an interference floor with which incumbent licensees would have to cope. The level at which this floor/ceiling level is a critical policy dimension. If the floor/ceiling were set low

enough—and if there were an absolute assurance that the ceiling would never be exceeded by those users permitted to operate beneath it—then creating underlay rights would have few costs and few benefits. As the level rises, the potential for creating benefits for underlay users rises, but so too does the potential for imposing significant costs on incumbent users.

15. In order to set a floor/ceiling at a level that will maximize the total dollar benefits generated from use of the spectrum, the Commission would have to know all of the potential uses, the values that consumers place on these uses, how different floors/ceilings affect the quality of service of these different uses, the values that consumers place on different quality levels, and the effects of various floors/ceilings on the costs and performance of transmitters and receivers for various uses.[2] In short, the Commission would need to collect and process tremendous amounts of information. No matter how competent the staff, the Commission simply does not have the ability to undertake this processing. Moreover, the Commission is ill equipped to elicit the necessary information from consumers, service providers, and equipment manufacturers. Simply asking various interest groups to declare their costs and benefits associated with various policy options is likely to elicit strategically distorted answers, not true dollar values.[3] There is a reason for the expression "put your money where your mouth is." The genius of the price system is that it aggregates huge amounts of information and it does so in a way that provides incentives for people to reveal their true

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[2] The Commission's public-interest objectives can go beyond maximization of economic efficiency as measured by aggregate net dollar benefits. Other, specific public-interest objectives may require targeted intervention on a limited scale (*e.g.,* broadcasting indecency standards) to supplement, but not entirely replace, reliance on market forces.

[3] In other words, the Commission does not have an incentive-compatible means of collecting the information necessary to implement efficient outcomes under command-and-control spectrum management policies such as the creation of mandatory underlay rights.

values.

16. Another problem with a government-dictated floor/ceiling is that it fails to promote cooperation among users on the two sides of the boundary. For instance, faced with a particular floor/ceiling that defines underlay rights, underlay users will have incentives to maximize the performance of their transmitters subject to the ceiling restraints, and will do so without direct regard for effects on the communications of incumbent license holders. Similarly, the incumbent license holders will have incentives to develop radio equipment that works well given the interference temperature floor, without regard for whether there are low-cost means of modifying their equipment so that underlay users could enjoy substantially greater benefits without interfering with communications by the incumbent licensees. Consequently, opportunities for improved economic efficiency through cooperation will go unrealized.[4]

17. One might try to correct these distortions by engaging in even more command and control, such as mandatory protocols, etiquettes, and receiver standards.[5] But the use of design and operation constraints will, almost by definition, necessarily distort investment decisions. Again, the Commission simply will lack the information needed to identify and implement policies that will dictate an efficient outcome. And, again, market forces can generally be expected better to create appropriate incentives.

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[4] In the light of the Coase Theorem, one might think that private bargaining could create market forces to ameliorate these problems even under a mandatory underlay rights regime. However, no private party would have necessary property rights to the floor/ceiling. There would, for example, be no mechanism for an underlay user to compensate an incumbent licensee for modifying its receivers to tolerate greater interference and then voluntarily raising the floor/ceiling.

[5] For example, the Commission is considering receiver interference immunity specifications, possibly as regulatory requirements. (*In the Matter of Interference Immunity Specifications and*

18. Yet another benefit of relying on a market-based process is that it can generate a variety of approaches to sharing spectrum, in particular, and using spectrum efficiently, in general. In principle, the Commission could adopt a variety of different approaches to measuring interference and defining and distributing underlay rights. In practice, however, it is difficult for the Commission to move quickly and flexibly on many policy fronts simultaneously.

19. The Spectrum Policy Task Force nicely summarized the situation as follows:

> [B]road application of the easement approach to operations above the interference temperature threshold presents significant challenges. Because the easement model inherently limits the flexibility afforded to the licensee to some degree, and relies on government to define the scope of the easement, it should be applied cautiously. (Task Force Report at 58.)

B. REGULATION GENERALLY IS NOT NEEDED TO INDUCE EFFICIENT USE OF UNDERLAY RIGHTS

20. As stated above, there is a broad consensus among economists and other policy analysts that market forces generally are preferable to regulation. Therefore, before concluding that regulation is needed to create and police the use of underlay rights, the Commission should ask whether market forces can be relied upon instead. Under this approach, market participants—both primary licensees and secondary licensees—would make tradeoffs among various ways to work together. Although the use of market forces has been criticized on market power and transactions costs grounds, neither of these criticisms undercuts the conclusion that economic efficiency would best be served by a market-based approach to spectrum management.

Review of the Commission's Rules and Policies Affecting Conversion to Digital Television, ET Docket No. 03-65 and MM Docket No. 00-39, Notice of Inquiry, rel. March 24, 2003.)

21. Some proponents of easements warn that exclusive rights holders will prefer to block access by other users in order to protect the rights holders' investments.[6] However, where there are multiple, competing licensees, such as in CMRS frequency bands, market power is unlikely to be a significant problem.[7] Each licensee has incentives to create an underlay if doing so will bring in revenues greater than the opportunity cost of the spectrum. Where there is competition, existing licensees have incentives to create and allocate underlay rights if doing so is efficient.

22. In the presence of transactions costs, markets might not achieve what is known as the first-best outcome. But it must be recognized that the Commission would also face transactions costs in implementing easements. Moreover, free markets have proven to be remarkably adept at overcoming transactions costs. Market institutions, such as private-sector band managers, frequency coordinators, rights clearinghouses, and equipment-based licensing fees can develop to mitigate the effects of transactions costs. Some policy analysts have called for the free distribution of underlay rights (a so-called unlicensed commons) based on the misconception that a market system cannot function well in situations where a large number of independent users would like to operate wireless devices for relatively low-value applications. But, in fact, there are several ways that such an arrangement could work on a commercial basis. For example, a license holder might sublicense underlay rights by charging equipment manufacturers a small per-unit or per-dollar royalty on their sales. This

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6 *Task Force Report* at 56.

7 The Spectrum Policy Task Force also reached the conclusion that market power generally will not be a problem: "The Task Force does not agree with commenters that contend that making an exclusive licensee the access 'gatekeeper'… will inhibit access by new technology, although there may be occasional instances of this type of restrictive behavior." (*Task Force Report* at 57.)

is not to say that competitive secondary markets always are optimal. There is, however, a strong presumption that, in most cases, competitive markets promote efficiency as effectively as is practicable.

IV. THE COMMISSION SHOULD BEWARE OF ADOPTING A SHORT-TERM PERSPECTIVE IN APPROACHING LONG-TERM ISSUES

23. The Commission should beware of adopting a short-term perspective to long-term issues of spectrum management. Bluntly put, the Commission is posing the wrong question when it asks "How would the costs and benefits of an interference temperature approach compare to the costs and benefits under the Commission's current spectrum policy?"[8] Rather, the Commission should ask: What spectrum-management policy reforms can be expected to lead to the greatest long-run benefits to consumers and the attainment of public-interest objectives?

24. The proposed policies represent an attempt to shoehorn additional spectrum users into specific frequency bands. For reasons discussed below, in many bands it is not clear that the Commission could find a floor/ceiling that both allowed significant underlay uses and fully protected incumbent licensees from harmful interference. Suppose, for the sake of argument, that the concept would work and underlay users would not interfere with the operations of existing users. Then these policies would give rise to a *short-run* Pareto improvement in economic welfare—new users would be better off and, by hypothesis, no existing user would be worse off. However, even the creation of these idealized underlay rights could be harmful from a long-run perspective. This is so because these policies could lock the Commission in

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[8] *NOI & NPRM*, ¶17.

to a perpetual system of command and control. Moreover, once locked in, the short-term reforms might block the realization of larger long-term efficiency gains. As discussed above, reliance on secondary markets can, at least in important instances, be expected to promote more efficient use of the spectrum than can Commission command and control. Secondary markets would, for example, promote greater coordination between primary licensees and underlay users, with the result that the net overall benefits derived from use of the spectrum would be greater than if government-mandated underlay rights were created.

25. The threat of policy lock-in just identified goes beyond what supporters of mandatory underlay rights might characterize as "the best is the enemy of the good." There is a danger that the policies creating mandatory underlay rights by fiat would become locked in even if they proved to be worse than the present status quo. For instance, suppose that after a large number of so-called unlicensed devices had begun operating under an easement, it was found that their operation harmed the operations of the incumbent licensed users. At that point, it might be difficult or impossible legally or politically to shut down operation of the unlicensed devices (*i.e.,* squatters' rights will have developed). Politics thus could lock in bad policies that benefit large numbers of consumers but also harm large numbers of other consumers as well as overall economic efficiency.

V. POLICIES BASED ON AN INTERFERENCE TEMPERATURE METRIC ARE NOT READY FOR IMPLEMENTATION

26. The previous section discussed the fact that, at a broad level, the creation of mandatory underlay rights based on an interference temperature metric may not be the policy that best promotes economic efficiency. The present section discusses the fact that the preliminary nature of the interference temperature metric may result in harmful consequences

for consumers of services in the licensed bands where underlay rights are mandated.

A. THE INTERFERENCE TEMPERATURE CONCEPT IS NOT FULLY DEVELOPED AND MAY BE THE WRONG MEASURE FROM THE PERSPECTIVES OF BOTH ENGINEERING AND ECONOMICS

27. It is not clear that interference temperature is the right measure even if one has already concluded that it is desirable for the government to mandate underlay rights. Ultimately, the concern of economic efficiency is with what might be termed economic interference. That is, with the effects of physical interference on the dollar costs and benefits realized by various parties from their use of the spectrum. It is far from evident that interference temperature fully and accurately measures physical interference, and it is unlikely that it adequately measures economic interference. For instance, the Commission would need to determine the point at which to measure interference temperature. The location of a transmitter whose user holds underlay rights is almost certainly the wrong point of measurement when dealing with many types of incumbent licensed applications. Instead, what is needed are measures of interference temperatures at receiver locations.[9] In order to implement efficient policies, the Commission would also need to collect and process the information needed to assign dollar values to various outcomes. Lastly, the Commission would have to determine how benefits are to be allocated and how the interference temperature metric fits within a broader policy of defining rights and obligations.

28. The Commission also currently lacks the ability to measure interference temperature

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[9] It is also my understanding that other characteristics of a signal beyond its contribution to interference temperature can be relevant to determining the degree of economic interference. Thus, it is my understanding that there are circumstances in which a user's high-power signal could more readily be dealt with by other users than could a lower power signal. I am not an engineer, and I raise these issues solely to illustrate the large number of questions that the Commission should address before moving forward.

and to enforce policies predicated on it. For example, there is no monitoring system in place. Moreover, even if offending users could be identified, enforcement issues have not been thoroughly thought through. Depending on the nature of the underlay rights that were created, the Commission might have to deal with a very large number of devices owned and operated by unsophisticated users.

B. THE COMMISSION IS NOT IN A POSITION TO MAKE INFORMED DECISIONS WITH RESPECT TO INTERFERENCE TEMPERATURE FLOORS/CEILINGS IN MANY BANDS

29. The Commission has correctly proposed to undertake selected experiments before widely applying the use of an interference temperature metric as the basis for defining mandatory underlay rights. While the Commission has formulated specific experiments for selected bands, the Commission has not formulated meaningful proposals for other bands. Given the costs of mistakes, an economic cost-benefit analysis of the policy process suggests that it would be preferable to develop fully formed proposals on which to seek comment before going further. Those proposals could then be modified, subject to limited trials, and—if the initial steps indicated that the approaches were worth pursuing—serve as the basis for large-scale experiments in selected frequency bands. As the extent and nature of the questions raised in the Notice of Inquiry make clear, the Commission is far from being ready to conduct large-scale experiments in CMRS bands.[10] Regardless of the long-run outcome, at this point the Commission simply does not know enough about the various tradeoffs to be made in many frequency bands to propose interference-temperature floors/ceilings even on an experimental basis.

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[10] *NOI & NPRM*, ¶¶18-28.

C. THE NOTICE OF INQUIRY MAKES MISLEADING CLAIMS ABOUT BENEFITS TO INCUMBENTS

30. The notice of inquiry in this proceeding asserts that incumbents will benefit from the use of interference temperature to create floors/ceilings.[11] There are two fundamental flaws with this argument. First, given the underdeveloped nature of the policy proposals and the lack of experience with interference-temperature-based underlay rights, it is far from clear that such policies would give rise to certainty. Second—even if the proposed policies were somehow reformulated so that they did provide certainty—it is far from evident that such certainty would be a benefit to incumbent licensees.

31. The Commission does not appear to have recognized that, in measuring the benefits of certainty, one needs to have an appropriate benchmark. For example, it is no benefit to an economic agent to be told that something bad will happen with certainty instead of with only a 50-percent chance. The Commission asserts that incumbents will benefit from certainty about the level of interference they face. But whether this certainty is a cost or benefit depends critically on the level at which the interference temperature floor/ceiling is set, as well as on how effectively actual interference is measured and the extent to which the policy is meaningfully enforced on a timely basis. Incumbents would benefit if the policy placed a fully enforced ceiling on potentially interfering users that resulted in less interference than would have occurred absent implementation of the policy (*e.g.,* if no underlay rights were created at all). But it is simply incorrect to assert that incumbents would benefit from the policy if the ceiling imposed on the underlay users allowed them to generate more interference than would have been allowed under the status quo. Even the certainty of a

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[11] *NOI & NPRM*, ¶15.

"perfectly" implemented interference temperature floor is no benefit to incumbents if it results in their facing increased interference in comparison with a policy of having no underlay rights created by the government.

VI. CMRS BANDS ARE NOT APPROPRIATE PLACES TO EXPERIMENT WITH MANDATORY UNDERLAY RIGHTS BASED ON INTERFERENCE TEMPERATURE

32. In the notice of proposed rulemaking in this proceeding, the Commission asks whether it is feasible and desirable to begin mandating underlay rights based on the interference temperature approach on a limited basis in selected bands.[12] In addition to suggesting specific frequency bands, the notice of proposed rulemaking requests comment on whether there are other frequency bands that would be suitable for testing the concept of mandatory underlay rights based on an interference-temperature metric.[13] For a variety of reasons, CMRS frequency bands are not an appropriate place to experiment with mandatory underlay rights based on interference temperature.

A. THERE IS A PARTICULARLY HIGH LIKELIHOOD OF INTERFERENCE

33. The nature of CMRS networks makes it particularly likely that the mandatory creation of underlay rights based on interference temperature will result in unintended and economically harmful interference with the operation of those networks. A typical CMRS network consists of a huge number of mobile transceivers. In order to provide convenience for users, these handsets typically have a form factor that limits their power and, in some respects, their sophistication. Thus, these mobile terminals can be very susceptible to

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[12] *NOI & NPRM*, ¶30.

[13] *Id.,* ¶31.

interference. Moreover, as the Commission recognizes, mobile transceivers greatly increase the complexity of the task of applying the interference temperature concept because of the difficulties determining which receivers will be affected and to what degree.[14] The problem is especially acute for these devices because huge numbers of them already are deployed that do not have the capability to collect and report interference temperature measurements that could be used to define the allowable actions of underlay rights users. Given the large numbers of deployed terminals, as well as their mobile form factors, it would be costly to implement such capabilities any time soon.

34. The threat of costly interference also arises because CMRS operators have engineered their systems to make intensive use of spectrum. As discussed in the CTIA comments to which this report is attached, CMRS carriers engineer their systems in ways that leave relatively little margin for error.[15]

B. INTERFERENCE WOULD BE PARTICULARLY HARMFUL

35. There are several reasons to conclude that interference with the primary users would be particularly costly in CMRS bands. First, there are consumer safety concerns. Mobile telephones play an important consumer safety role, such as 9-1-1 and other emergency calls. Moreover, these services are very valuable to consumers even when not being used for consumer safety. Examples of high-value uses include a parent's arranging to pick up a child

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[14] "The key simplifying benefit of dealing with fixed operations is the fact that such operations are generally static and well-defined such that reasonable assumptions can be made about their locations and technical characteristics." (*NOI & NPRM*, ¶34.) CMRS is at the opposite extreme.

[15] The Cellular Telecommunications & Internet Association, *In the Matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands,* Comments, ET Docket No. 03-237, submitted April 5, 2004.

after school and a small business owner's informing a client that she is going to be late for an appointment.

36. In addition to the intensity of effects on individuals, there is also the fact that large numbers of consumers could be affected by harmful interference. Moreover, if there were problems that required adaptation by CMRS service providers or their customers, these problems could prove very costly because of the large number of handsets and cell sites that could be involved in a fix.

C. CONCERNS ABOUT HARM TO INNOVATION AND INVESTMENT ARE PARTICULARLY STRONG

37. The creation of significant mandatory underlay rights would very likely reduce the incentives and ability of CMRS incumbent licensees to innovate and invest. These investment and innovation distortions would harm consumers and economic efficiency.

38. It is widely documented that, over the years, CMRS carriers and their equipment vendors have developed and deployed numerous technological improvements (*e.g.,* digital systems and spread spectrum techniques) that have dramatically increased the capacities of their wireless systems in terms of the numbers of subscribers served and the array of services offered. CMRS carriers have made billions of dollars of investment in their wireless networks, and these investments have created large consumer benefits.

39. CMRS providers can be expected to continue to innovate and invest in ways that allow them to generate more economic value from their licensed spectrum—if market forces are allowed to operate. CMRS providers can be expected both to invest in new technologies

to make new and greater use of the spectrum themselves (*e.g.,* roll out various forms of broadband networks) and to create underlay rights or sharing mechanisms, where efficient.[16]

40. For at least three reasons, reliance on secondary markets and other economic incentives can be expected to lead to more efficient deployment of broadband wireless networks and other new technologies than would creation of government-mandated underlay rights. First, as discussed above, market forces can be expected to create greater incentives to design and deploy receivers and transmitters operated by different users that can co-exist efficiently.

41. Second, mandatory interference-temperature-based underlay rights will create greater uncertainty for CMRS providers. The uncertainty about actual levels of interference will result in some combination of lower service quality or higher costs (to mitigate the effects of the interference) and thus lower economic returns to additional investments in CMRS networks.

42. A third, and closely related, reason that reliance on market forces can be expected to lead to more efficient innovation and investment than would the imposition of mandatory underlay rights is that the latter may adversely affect the expectations of potential investors and innovators. CMRS carriers have made billions of dollars of investments in technology

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[16] According to the Spectrum Policy Task Force,

> Thus, the secondary market approach has significant potential to foster opportunistic technologies, such as agile-frequency-hopping radios, software defined radios, and adaptive antennas, at reasonable transaction costs. In fact, it is anticipated that as the access-enhancing potential of these technologies continues to improve, exclusive licensees will often wish to encourage and even develop such technologies in order to provide new services and devices and serve more customers. (*Task Force Report* at 57.)

and equipment based on their beliefs about the interference protections that they receive under their spectrum licenses. Incumbent licensees built out their systems and made numerous technical decisions in reliance on governmental policies that restrain third parties from creating harmful interference. The returns earned on these investments could be seriously diminished if the Commission's new policies were to result in significantly less effective protection from interference. Although past investments are largely sunk costs at this point, the Commission's policies could adversely affect *future* investment and innovation by CMRS carriers, as well as by other service providers whose use of the spectrum is subject to Commission jurisdiction. These adverse effects will arise when the Commission's policies create investor concern that the Commission will adopt other policies in the future that will similarly harm investments then in place.[17]

VII. CONCLUSION

43. The Commission has correctly determined that there is a need for dramatic and systematic reform of spectrum management. To its credit—and to the benefit of telecommunications consumers—the Commission is engaged in the sort of wholesale rethinking of spectrum management that is needed to increase significantly the economic efficiency of wireless communications in the United States. Although the Commission faces tremendous pressures to reform spectrum management in ways that will increase the economic efficiency of spectrum use in the short run, the long-run effects ultimately are more

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[17] In a slightly different context, the Spectrum Policy Task Force identified "[t]he nature and extent of investments made by incumbents in their acquisition of licenses and the building of systems, including whether incumbents have had the opportunity to recoup their investments" as a "major factor" to consider when choosing the appropriate spectrum management policy for a given frequency band. (*Task Force Report* at 49 and 50.)

important to consumer welfare.

44. The Commission should move with deliberate speed to reform spectrum management, but it should not rush to implement reforms that may have adverse long-run effects. Specifically, the Commission should take care not to implement unproven policies that could prove difficult to reverse even if they are later found to be inefficient. Moreover, the Commission should undertake policy reform with the recognition that it is extremely unlikely that the Commission will soon get another chance to undertake major reforms if it gets it wrong this time around.

45. For the reasons above, I conclude that now is not the time to create mandatory underlay rights in CMRS frequency bands based on the interference temperature metric.

CURRICULUM VITAE OF MICHAEL L. KATZ

Haas School of Business
University of California at Berkeley
Berkeley, CA 94720-1900

katz@haas.berkeley.edu

EMPLOYMENT

July 1987 to present

Sarin Professor of Strategy and Leadership
University of California at Berkeley

Joint appointment in the Economics Department and School of Business. Initial appointment to associate professor July 1987. Promoted to full professor July 1989. Granted an endowed chair July 1995. Research areas include antitrust policy, innovation, and telecommunications pricing. Past chair of Strategic Planning Committee, Policy and Planning Committee, and the Economic Analysis and Policy Group. Former Associate Dean for Academic Affairs. Principal teaching in areas of business strategy and microeconomics.

September 2001 to January 2003

Deputy Assistant Attorney General for Economic Analysis
U.S. Department of Justice

Oversaw economic analysis in support of all Antitrust Division enforcement activities. Reported directly to the Assistant Attorney General for Antitrust. Managed unit of approximately 55 professional economists. Undertook multidimensional effort to integrate economists more fully into investigation, decision, and litigation processes.

January 1994 to January 1996

Chief Economist
Federal Communications Commission

Responsible for integrating economics into all aspects of Commission policy making. Reported directly to the Chairman of the Commission. Formulated and implemented regulatory policies for all industries under Commission jurisdiction, including cable and broadcast television, and local, long distance, and wireless telephony. Managed teams of lawyers and economists to design regulatory policies and procedures.

July 1981 to June 1987

Assistant Professor of Economics
Princeton University

Conducted research on sophisticated pricing, standards development, cooperative R&D, and intellectual property licensing. Served as Assistant Director of Graduate Studies. Taught courses in microeconomics, industrial organization, and antitrust and regulation to undergraduate and doctoral students.

EDUCATION

D.Phil. 1982
Oxford University
Doctorate in Economics. Thesis on market segmentation and sophisticated pricing strategies.

A.B. *summa cum laude* 1978
Harvard University
As an undergraduate, completed all courses and general examinations for doctorate in economics.

AWARDS AND HONORS

Chairman's Special Achievement Award, Federal Communications Commission, 1996.
The Earl F. Cheit Outstanding Teaching Award, University of California, Berkeley, 1992-1993 and 1988-1989. Honorable Mention, 1999-2000 and 1996-1997.
Alfred P. Sloan Research Fellow, 1985-1988.
National Science Foundation Graduate Fellow, 1978-1981.
John H. Williams Prize (awarded to the Harvard College student graduating in Economics with the best overall record), 1978.
National Merit Scholar, 1975-1976.

GRANTS

Recipient, Berkeley Committee on Research grant, 1996-1997.
Recipient, Berkeley Program in Finance Research grant, 1990.
Researcher, Pew Foundation grant: "Integrating Economics and National Security," 1987-1990.
Principal Investigator, National Science Foundation grants:
- "A More Complete View of Incomplete Contracts," joint with Benjamin E. Hermalin, 1991-1993.
- "Game-Playing Agents and the Use of Contracts as Precommitments," 1988-1989.
- "The Analysis of Intermediate Goods Markets: Self-Supply and Demand Interdependence," 1985-1986.
- "Imperfectly Competitive Models of Screening and Product Compatibility," 1983-1984.
- "Screening and Imperfect Competition Among Multiproduct Firms," 1982.

PROFESSIONAL SERVICE

Coeditor, *Journal of Economics & Management Strategy,* 1991-2001 and 2003-present.

Editorial Board member, *California Management Review,* 1998-2000 and 2003-present. Editor 2000-2001.

Member, Computer Science and Telecommunications Board, The National Academies, 2000-2001.

Member, Consumer Energy Council of America, Universal Service Forum, 2000-2001.

Member, Committee on Wireless Technology Prospects and Policy Options, The National Academies, October 2003-present.

Pro bono consulting for U.S. Federal Communications Commission and the telecommunications regulatory agencies of several developing nations.

PUBLICATIONS

"Multiplant Monopoly in a Spatial Market," *Bell Journal of Economics* Vol. 11, No. 2 (Autumn 1980).

"Non-uniform Pricing, Output and Welfare Under Monopoly," *Review of Economic Studies* Vol. L, No. 160 (January 1983).

"A General Analysis of the Averch-Johnson Effect," *Economic Letters* Vol. 11, No. 3 (1983).

"The Socialization of Commodities," co-authored with L.S. Wilson, *Journal of Public Economics* Vol. 20, No. 3 (April 1983).

"The Case for Freeing AT&T," co-authored with Robert D. Willig, *Regulation* (July/August 1983) and "Reply to Tobin and Wohlstetter," *Regulation* (November/December 1983).

"Plea Bargaining and Social Welfare," co-authored with Gene M. Grossman, *American Economic Review* Vol. 73, No. 4 (September 1983).

"Firm-Specific Differentiation and Competition Among Multiproduct Firms," *Journal of Business* Vol. 57, No. 1, Part 2 (January 1984).

"Nonuniform Pricing with Unobservable Numbers of Purchases," *Review of Economic Studies* Vol. LI (July 1984).

"Price Discrimination and Monopolistic Competition," *Econometrica* Vol. 52, No. 6 (November 1984).

PUBLICATIONS continued

"Tax Analysis in an Oligopoly Model," co-authored with Harvey S. Rosen, *Public Finance Quarterly* Vol. 13, No. 1 (January 1985). Reprinted in *The Distribution of Tax Burdens*, D. Fullerton and G.E. Metcalf (eds.), Camberley: Edward Elgar Publishing Ltd. (2003).

"Network Externalities, Competition, and Compatibility," co-authored with Carl Shapiro, *American Economic Review* Vol. 75, No. 3 (June 1985).

"On the Licensing of Innovations," co-authored with Carl Shapiro, *Rand Journal of Economics* Vol. 16, No. 4 (Winter 1985).

"Consumer Shopping Behavior in the Retail Coffee Market," co-authored with Carl Shapiro, in *Empirical Approaches to Consumer Protection* (1986).

"Technology Adoption in the Presence of Network Externalities," co-authored with Carl Shapiro, *Journal of Political Economy* Vol. 94, No. 4 (August 1986).

"How to License Intangible Property," co-authored with Carl Shapiro, *Quarterly Journal of Economics* Vol. CI (August 1986).

"An Analysis of Cooperative Research and Development," *Rand Journal of Economics* Vol. 17, No. 4 (Winter 1986).

"Product Compatibility Choice in a Market with Technological Progress," co-authored with Carl Shapiro, *Oxford Economic Papers: Special Issue on Industrial Organization* (November 1986).

"The Welfare Effects of Third-Degree Price Discrimination in Intermediate Goods Markets," *American Economic Review* Vol. 77, No. 2 (March 1987).

"R&D Rivalry with Licensing or Imitation," co-authored with Carl Shapiro, *American Economic Review* Vol. 77, No. 3 (June 1987).

"Pricing Publicly Provided Goods and Services," in *The Theory of Taxation for Developing Countries*, D.M. Newbery and N.H. Stern (eds.), Washington, D.C.: World Bank (1987).

"Vertical Contractual Relationships," in *The Handbook of Industrial Organization*, R. Schmalensee and R.D. Willig (eds.), Amsterdam: North Holland Publishing (1989).

"R&D Cooperation and Competition," co-authored with Janusz A. Ordover, *Brookings Papers on Economic Activity: Microeconomics* (1990).

PUBLICATIONS continued

Intermediate Microeconomics, co-authored with Harvey S. Rosen, Burr Ridge, IL: Richard D. Irwin (1st ed. 1991, 2nd ed. 1994, 3rd ed. 1997).

"Game-Playing Agents: Unobservable Contracts as Precommitments," *Rand Journal of Economics* Vol. 22, No. 3 (Autumn 1991).

"Moral Hazard and Verifiability: The Effects of Renegotiation in Agency," co-authored with Benjamin E. Hermalin, *Econometrica* Vol. 59, No. 6 (November 1991).

"Product Introduction with Network Externalities," co-authored with Carl Shapiro, *Journal of Industrial Economics* Vol. XL, No. 1 (March 1992).

"Defense Procurement with Unverifiable Performance," co-authored with Benjamin E. Hermalin, in *Incentives in Procurement Contracting*, J. Leitzel and J. Tirole (eds.), Boulder, Colorado: Westview Press (1993).

"Judicial Modification of Contracts Between Sophisticated Parties: A More Complete View of Incomplete Contracts and Their Breach," co-authored with Benjamin E. Hermalin, *Journal of Law, Economics, & Organization* Vol. 9, No. 2 (1993).

"Systems Competition and Network Effects," co-authored with Carl Shapiro, *Journal of Economic Perspectives* Vol. 8, No. 2 (Spring 1994).

"Joint Ventures as a Means of Assembling Complementary Inputs," *Group Decision and Negotiation* Vol. 4, No. 5 (September 1995). Also printed in *International Joint Ventures: Economic and Organizational Perspectives*.

"Interconnecting Interoperable Systems: The Regulator's Perspective," co-authored with Gregory Rosston and Jeffrey Anspacher, *Information, Infrastructure and Policy*, Vol. 4, No. 4 (1995).

"Interview with an Umpire," in *The Emerging World of Wireless Communications,* Annual Review of the Institute for Information Studies (1996).

"An Analysis of Out-of-Wedlock Childbearing in the United States," co-authored with George Akerlof and Janet Yellen, *Quarterly Journal of Economics* Vol. 111, No. 2 (May 1996).

"Remarks on the Economic Implications of Convergence" *Industrial and Corporate Change* Vol. 5, No. 4 (1996).

“Regulation to Promote Competition: A first look at the FCC’s implementation of the local competition provisions of the telecommunications act of 1996,” co-authored with Gerald W. Brock, *Information Economics and Policy* Vol. 9, No. 2 (1997).

PUBLICATIONS continued

"Ongoing Reform of U.S. Telecommunications Policy," *European Economic Review* Vol. 41 (1997).

"Economic Efficiency, Public Policy, and the Pricing of Network Interconnection Under the Telecommunications Act of 1996," in *Interconnection and the Internet: Selected Papers from the 1996 Telecommunications Policy Research Conference,* G. Rosston and D. Waterman (eds.), Mawah, New Jersey: Lawrence Erlbaum Associates, Publishers (1997).

"Introduction: Convergence, Competition, and Regulation," co-authored with Glenn A. Woroch, *Industrial and Corporate Change* Vol. 6, No. 4 (1997).

"Public Policy and Private Investment in Advanced Telecommunications Infrastructure," co-authored with Joseph Farrell, *IEEE Communications Magazine* (July 1998).

"The Effects of Antitrust and Intellectual Property Law on Compatibility and Innovation," co-authored with Joseph Farrell, *The Antitrust Bulletin* Vol. 43, No. 3/4 (Fall/Winter 1998).

"Antitrust in Software Markets," co-authored with Carl Shapiro, in *Competition, Innovation and the Microsoft Monopoly: Antitrust in the Digital Marketplace*, J.A. Eisenach and T. Lenard (eds.), Boston: Kluwer Academic Publishers (1999).

"Regulation: The Next 1000 Years" in *Six Degrees of Competition: Correlating Regulation with the Telecommunications Marketplace*, Washington, D.C.: Aspen Institute (2000).

"The Business of Health Care Affects Us All: An Introduction," co-authored with Sara Beckman, *California Management Review* Vol. 43, No. 1 (Fall 2000).

"Innovation, Rent Extraction, and Integration in Systems Markets," co-authored with Joseph Farrell, *Journal of Industrial Economics* Vo1. XLVIII, No. 4 (December 2000).

"Diversification and Agency," co-authored with Benjamin Hermalin, in *Incentives, Organization, and Public Economics: Papers in Honour of Sir James Mirrlees,* P. Hammond and G. D. Myles (eds.), Oxford University Press (2001).

"Thoughts on the Implications of Technological Change for Telecommunications Policy," in *Transition to an IP Environment,* Washington, D.C.: Aspen Institute (2001).

"An Economist's Guide to *U.S. v. Microsoft*" co-authored with Richard Gilbert, *Journal of Economic Perspectives* Vol.15, No. 2 (Spring 2001).

PUBLICATIONS continued

"When Good Value Chains Go Bad: The Economics Indirect Liability for Copyright Infringement," co-authored with Richard Gilbert, *Hastings Law Journal* Vol. 52, No. 4 (April 2001).

"Intellectual Property Rights and Antitrust Policy: Four Principles for a Complex World," *Journal on Telecommunications & High Technology Law* Vol. 1, Issue 1 (2002).

"Recent Antitrust Enforcement Actions by the U.S. Department of Justice: A Selective Survey of Economic Issues," *Review of Industrial Organization* Vol. 21, No. 4 (December 2002).

"Critical Loss: Let's Tell the Whole Story," co-authored with Carl Shapiro, *Antitrust* Vol. 17, No. 2 (Spring 2003).

"Retail Telecommunications Pricing in the Presence of External Effects," co-authored with Benjamin Hermalin, in *International Handbook on Emerging Telecommunications Networks,* G. Madden (ed.), Camberley: Edward Elgar Publishing Ltd. (2003).

"Television Over the Internet: Industry Structure and Competition Absent Distribution Bottlenecks," in *Internet Television,* Noam, Groebel, and Gerbarg (eds.), Mawah, New Jersey: Lawrence Erlbaum Associates, Publishers (2003).

"The Role of Efficiency Considerations in Merger Control: What We Do in the U.S." in *EC Merger Control: A Major Reform in Progress,* G. Drauz and M. Reynolds (eds.), Richmond, England: Richmond Law & Tax Ltd. (2003).

"Market Structure, Organizational Structure, and R&D Diversity," co-authored with Joseph Farrell and Richard J. Gilbert, in *Economics for an Imperfect World: Essays in Honor of Joseph Stiglitz,* Arnott, Greenwald, Kanbur, and Nalebuff (eds.), Cambridge, MA: MIT Press (2003).

"Further Thoughts on Critical Loss," co-authored with Carl Shapiro, *The Antitrust Source* (March 2004). Available at http://www.abanet.org/antitrust/source/.

"Antitrust or Regulation: U.S. Public Policy in Telecommunications Markets," in *New Perspectives for European Antitrust and Regulation in Telecommunications* (tentative title), Camberley: Edward Elgar Publishing Ltd., in press.

"Sender or Receiver: Who Should Pay to Exchange an Electronic Message?" co-authored with Benjamin Hermalin, *Rand Journal of Economics,* in press.